Risk Analysis Group

Annual Progress Report 1984

Risø National Laboratory, Roskilde

Publication date:
1985

Document Version
Publisher's PDF, also known as Version of record

Risø-M-2512

RISØ

Risø-M-2512

Risk Analysis Group Annual Progress Report 1984

Risø National Laboratory, DK-4000 Roskilde, Denmark
June 1985

Risø-M-2512

RISK ANALYSIS GROUP
ANNUAL PROGRESS REPORT 1984

Abstract. The activities of the Risk Analysis Group at Risø during 1984 are presented. These include descriptions in some detail of work on general development topics and risk analysis performed as contractor.

INIS Descriptors. PROBABILISTIC RISK ASSESSMENT; RELIABILITY EXERCISE; THERMODYNAMIC ANALYSIS; LOCA; COMPUTER-AIDED RISK ANALYSIS; DESIGN ERROR; UNWANTED CHEMICAL REACTIONS; OFFSHORE; TRAFFIC SYSTEMS; SEVESO DIRECTIVE; RISOE NATIONAL LABORATORY.

June 1985
Risø National Laboratory, DK-4000 Roskilde, Denmark

ISBN-87-550-1130-6
ISSN 0418-6435

Risø Repro 1985

CONTENTS

Page

1. INTRODUCTION 1

2. DEVELOPMENT OF METHODS AND TOOLS 2
   2.1. Probabilistic Risk Assessment and Licensing 2
   2.2. European Reliability Benchmark Exercise 4
   2.3. Computer Program for Thermodynamic Analysis of Species Created During a LOCA 8
   2.4. Computer-aided Risk Analysis 9
   2.5. Design Error in the Chemical Industry 10
   2.6. Unwanted Chemical Reactions in the Chemical Process Industries 11

3. RISK ASSESSMENT 12
   3.1. Offshore Oil & Gas Production 12
   3.2. Risk Assessment Used as a Tool in Selection between Alternative Traffic Systems 15
   3.3. Implementation of the Seveso Directive 16

4. COMPUTER PROGRAMS 17

5. PUBLICATIONS 20

6. STAFF 21

7. REFERENCES 24

1. INTRODUCTION

The activities of the Risk Analysis Group in 1984 covered a wide range of subjects including development of methods and tools and risk assessments. The various tasks undertaking are carried out either as basic R & D studies or under contract with different organisations or companies in Denmark and abroad.

Research and development concerning reliability and risk analysis at Risø has its origin in nuclear power. The decision concerning nuclear power in Denmark was postponed several times and finally, very recently, it was decided not to include nuclear power as an energy source in Denmark.

As a result the expertise, methods and tools developed are now utilized in the non-nuclear sector. A formal collaboration among four Risø departments was set up primarily with the purpose of performing risk and safety analyses for industry and the public sector. The main projects were a risk analysis of a chlorine production and storage facility in the centre of Copenhagen, a safety analysis of an oil production platform in the Danish part of the North Sea and a risk analysis of a chemical waste treatment plant.

The Risk Analysis Group was formed by joining personnel from the departments of Energy Technology and Electronics, because of the increasing demand for risk and safety analyses. Furthermore, the Danish authorities are in the process of implementing the so-called "Seveso directive", which calls for risk assessment of a large part of the chemical industry in Denmark.

In the following, short descriptions are given of the projects and analyses in which the group has been engaged during 1984. Also two PhD studies are described together with a listing of the computer programs available. The area covered is very broad indeed ranging from risk analyses for offshore platforms to studies of design errors in the chemical industry and risk comparison for two traffic systems (bridge/tunnel).

Finally, it can be mentioned that the Risk Analysis Group and the Energy Systems Group at Risø from January 1985 jointly have formed a new Systems Analysis Department. The present activities of the two groups will continue within the new department.

2. DEVELOPMENT OF METHODS AND TOOLS

2.1. Probabilistic Risk Assessment and Licensing

The Nordic project NKA/SÄK-1, Probabilistic Risk Assessment and Licensing, has been carried out within the research program of the Nordic Liaison Committee for Atomic Energy in the period 1981-84. Risø has participated in the work with an effort of approximately 1.5 person years per year.

The project has been aimed at verification and comparison of the methods and data bases used in a Level 1 PRA, i.e. functional modelling and probabilistic evaluation of accident sequences. The project has also been aimed at presentation of the guidelines for the application of probabilistic methods in the regulatory work.

The main effort in 1984 was concentrated on completing the benchmark exercise concerning sequences starting with loss of off-site power and ending with automatic depressurization at the Barsebäck nuclear power plant. Several supplementary analyses have been performed in order to study in detail the impact of human errors, common cause failures, and simplified modelling of functional responses.

Another major task has been the writing of the final report which will be printed and distributed in the spring 1985. The results of the project were presented at two workshops. A workshop concerning PRA in Licensing was convened in May in Täljöviken in Sweden. An expert workshop was convened in November in

Lidingö in Sweden covering the main areas of work within the project and with participants from the research institutes, utilities, and authorities from the Nordic countries.

As a result of the two benchmark studies performed, better insight has been obtained concerning the advantages and limitations of modelling techniques. It is recommended that the modelling be done hierarchically starting from a simple model and adding detailed submodels as needed, using different methods on different levels of hierarchy.

Statistical techniques and computer programs have been developed for handling failure records. The principles and methods are adopted in use in the Nordic PRA-studies and in the compilation of the Swedish Data Bank (ATV system).

Furthermore, the results of the project will be reviewed with respect to applicability in the non-nuclear field. This work will be performed during the spring 1985 and reported separately.

Still a lot of important research work remains to be done. Areas were identified in the project and they are included in two new projects in the NKA program for 1985-88. The first project concerns risk analysis. The objective is the continued work with uncertainty treatment, completeness question, CCF analysis, and human error analysis. A more challenging benchmark study is planned covering human error analysis and the completeness question. The second project concerns optimization of technical specifications. This is a practically oriented project with the aim of applying PRA methods in the balancing of test and repair arrangements in the safety systems.

2.2. European Reliability Benchmark Exercise

The European Reliability Benchmark Exercise (RBE) was started by the JRC, Ispra on the initiative of the EEC working group 2 on Light Water Reactor Safety. Further, the JRC, Ispra also provided a secretariat for the project.

In total 17 organisations from eight European countries participated in the analysis, which was carried out from September 1981 to October 1983. The final report was delayed and is expected to be published in 1985.

The objectives of the RBE were:

I: to demonstrate the maturity of the discipline with its advantages and limitations,

II: to assess the degree of consistency among the results obtained by different organizations and/or different methods, and

III: to attempt to define common analysis procedures with possible variants.

The RBE was a reliability analysis of a system, the auxiliary feedwater system in one of the 1300 MWe PWR power plants in Paluel, France, as proposed by Electricité France (EDF).
A simplified diagram for this system is presented in Fig. 1.

The top event for the analysis, i.e. the situation for which the probability of occurrence should be evaluated was specified as the following: Start of the system and delivery of the necessary feedwater flow during a 7.5 hour operation period in case of failure of the normal feedwater line. (Fig. 1).

The qualitative analysis comprised: Component failure mode and effects analysis, a common cause failure analysis, a human failure analysis and a cause consequence analysis.

The final calculation of the probability of the top event was performed both with MOCARE, a Monte Carlo simulation program developed by the risk analysis group and with FAUNET, an analytical program developed by the Electronics Department. Good agreement was obtained between the MOCARE and FAUNET calculations.

The results of the calculations performed by the participants in the RBE exhibited considerable spread, due to differences in the fault trees - to some extent caused by differences in the boundaries of the problem - as well as in the data. The results and their overall spread are presented in Fig. 2. This figure also shows that all calculations on the common fault tree using common data gave the same result; in other words, the various computational methods used caused no differences in the results.

As far as the objectives of the exercise are concerned, the Risø team is of the opinion that items 1 and 3 have not been achieved - more work seems necessary.

One of the findings from the benchmark analysis was that vital areas require further work, in particular common cause failure and human errors. Further, it was demonstrated that logical modelling by manual means is a rather time-consuming job involving a risk of not being "complete". Thus, it seems advisable that a fault tree construction is being assisted by a computer.

More emphasis should be given to the data aquisition in order that the data are as appropriate as possible and refer more to experience with equipment, which is identical to and was operated and maintained under the same conditions as the analysed equipment.

The European cooperation, which was initiated with the Reliability Benchmark Exercise, will be continued over the period 1985-1987 in three new benchmark exercises on the following subjects:

common cause failures,
human errors, and
integrated event sequence analysis.

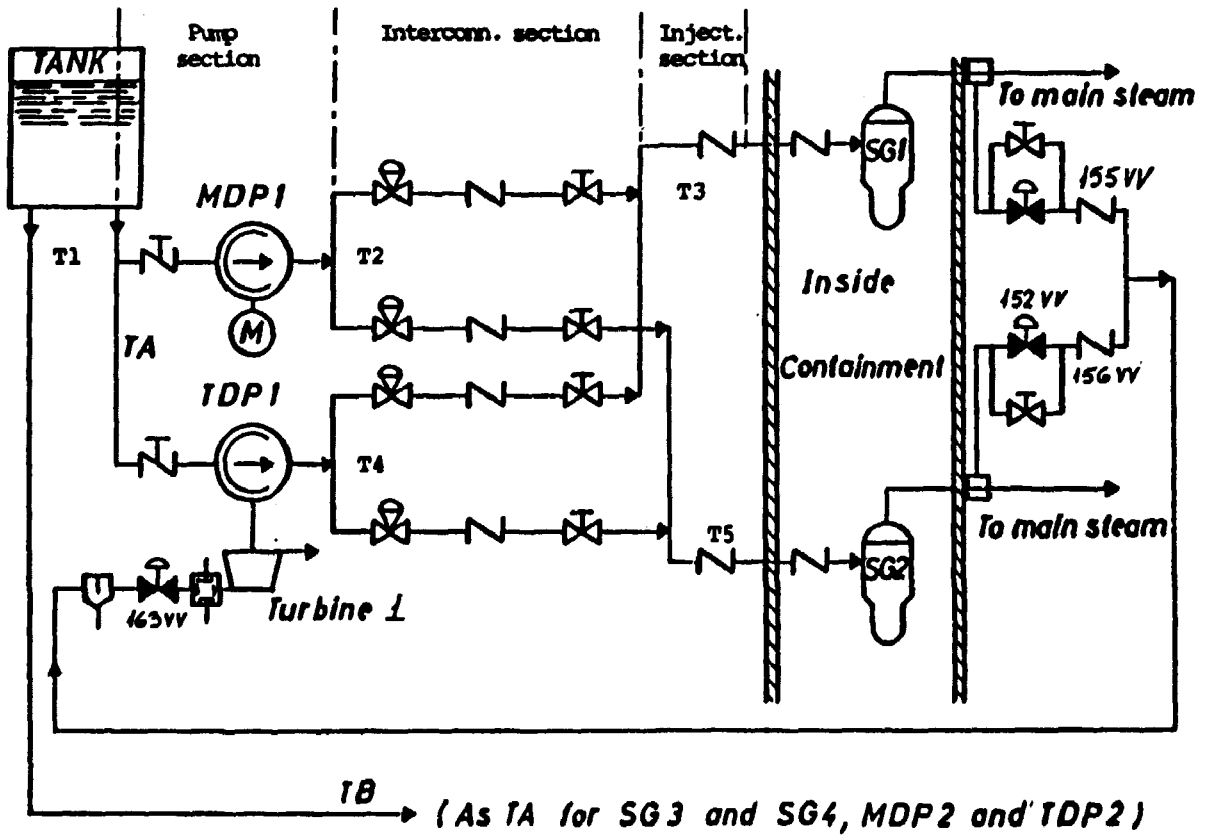

Fig. 1. Simplified diagram of the auxiliary feedwater system in one of the Paluel PWR power plants.

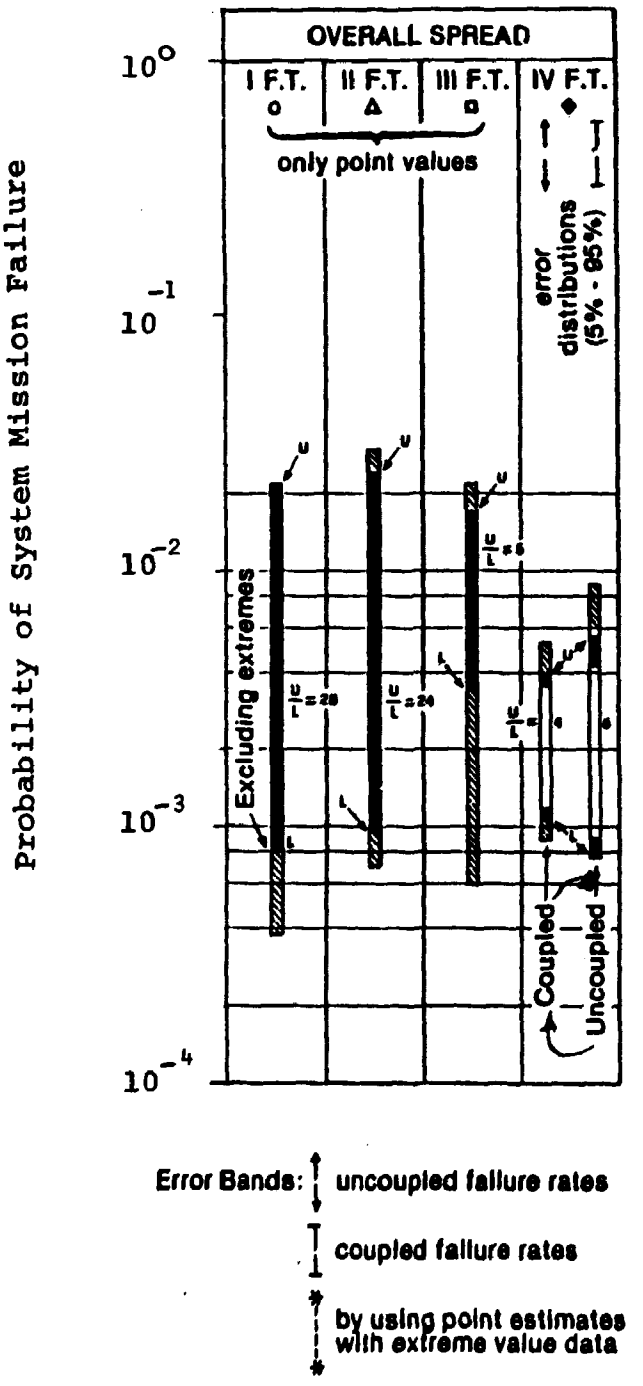

Fig. 2. Probabilistic results of the RBE.

2.3. Computer Program for Thermodynamic Analysis of Species Created during a LOCA

A computer code, CELEQ, has been developed with the purpose of facilitating the description of the nature and amount of chemical species created during a LOCA resulting in fuel failure in a nuclear reactor. This program performs a thermodynamic analysis on a specified system to determine the most stable species as a function of temperature, pressure and composition. The analysis gives a fairly detailed description of the system under the assumption that equilibrium is obtained. With the CELEQ code it is possible to perform a sequence of calculations both in time and in different compartments.

For each step the code requires information about temperature, pressure and the elemental abundances both of the fission products and of hydrogen, oxygen and nitrogen. These figures will be the result of a computation performed by a computer code, RELCON, developed by ELSAM/Jensen/. The user of CELEQ must specify compounds of interest and the appropriate thermodynamic data. There will be an option for specifying whether the compound is in the solid, liquid, or gas phase.

The central part of the CELEQ code is an equilibrium calculator developed by W.R. Smith/Smith/. The algorithm is based on a nonstoichiometric formulation of the chemical equilibrium problem and the conservation of the elemental abundances.

The CELEQ code will produce a listing of the computed equilibrium concentrations of the compounds specified as a function of time and compartment.

The development of the code was performed by Risø as a contract assigment for the Danish utility group ELSAM. The work has been done in co-operation with the Aerosol Group at the Energy Technology Department.

2.4. Computer-aided Risk Analysis

Since 1978 the development of programs for fault tree construction and calculation, and cause consequence diagram analysis have been going on.

The work has resultet in a program package, RIKKE, which is an automatic fault tree construction program. RIKKE consists of a graphic input module, a fault tree generator, a fault tree calculation module and different libraries of component models. The program works on the basis of a flow sheet for the system. During an interactive process the model of the system is constructed using the libraries of component models. The fault tree corresponding to the model is generated automatically and quantified if needed.

The package is mostly used for supporting the design of nuclear power plants and process industry plants. According to a flexible library system it has also been fitted for testing electrical control systems, rocket launch systems, etc.

In 1984 this development reached a final state level where the system was systematically, checked and an adequate documentation written.

Further, the system has been moved on to a VAX/11-750 VMS computer, from Digital Equipment Cooperation, which gives the capacity for working with new monitor types and extra plotter drivers. By this effort it has been possible to meet aims from commercial risk analysis.

By the end of 1984 the RIKKE-package or part of it was running in several versions spread over England, the Netherlands, Suomi Finland, West Germany, Sweden and Denmark.

2.5. Design Error in the Chemical Industry

A design error study, performed as part of a Ph.D. dissertation, was completed in the summer 1984, and a report including the results has been issued.

The role of design errors and the use of risk and safety analysis methods in design in the chemical process industry has been investigated. 860 accident case stories from the process industry were analysed, and in 215 cases (25%) design errrors were detected. This is in accordance with other studies. A detailed study of the 215 design error cases has provided information about when, how, and why the error was made, what the consequences were, and which safety analysis techniques might have revealed the problem.

It seems possible to discover the majority of the design errors by integrating already known risk analysis methods into the design process. It was judged that hazard and operability study, action error analysis (a method which scrutinises the procedures) and inspection on site would have revealed the problem leading to the accident occurring in 84% of the design error cases. Some design errors call for new checklists or methods especially aimed at covering the three-dimensional piping arrangements, maintenance and repair, and situations where chemicals come into contact with operators.

Direct observation and interviews in design and safety offices of around 20 major companies (both contractors and operating companies) and institutions provided details about the design process, the differences in design organisations and the risk and safety analysis methods used.

The emphasis on safety analysis methods shows a surprising variation between different companies, and about half of the companies have integrated a hazard and operability study in the design process.

The recommendations made are to integrate hazard and operability study and action error analysis into the design process.

2.6. Unwanted Chemical Reactions in the Chemical Process Industries

A Ph.D. study concerning unwanted and dangerous chemical reactions in the chemical process industries has been initiated in summer 1984. The work is expected to be completed in 1987. The purpose of the project is to improve the existing methods in safety and risk analysis, especially those concerning dangerous chemical reactions.

As the first part of the project an accident case study is carried out. The purpose of the case study is to examine the circumstances and causes leading to unwanted chemical reactions. The systematic used in the case story study is:

- classification (includes among other things: occupancy class, type of hazardous materials, type of compounds involved), and
- cause-consequence analysis (initiation mechanism, causes, consequences (humans, environment, materials)).

At the moment the second part of the project is planned to be a more detailed investigation of a few accidents that occurred in the Danish chemical process industry.

3. RISK ASSESSMENT

3.1. Offshore Oil & Gas Production

The development of Danish oil- and gasfields in the North Sea implies that development plans and modifications of existing plants are subjected to risk analyses which are used in design and for approval by authorities. In 1984 in collaboration with the Danish consulting firm Cowiconsult A/S the following tasks have been performed for Maersk Oil and Gas A/S:

Assessment of Shift in Risks due to Change of Flow Conditions in Pipelines and Risers

In 1984 the flow in an existing subsea pipeline between the Dan and Gorm Fields was changed from stabilized crude oil to a two-phase mixture of oil and gas. In order to improve the basis for decisions caused by this change, a risk assessment was made with the purpose of estimating fatality and pollution risks before and after the change took place.

The calculated individual risk figure - valid for the "future situation" - was finally compared with the historical fatality rate for Norwegian fixed platforms.

Risk Assessment of the Rolf (Middle Rosa) Offshore Platform project.

The Rolf field is situated west of the Gorm field in the North Sea. A development project proposal including a new platform and modifications to existing platforms was analysed.

New Platform Concept

The platform projected is an unmanned, remotely controlled one-leg design. During operation, personnel will be present only for short periods for the purpose of inspection, start-up or maintenance.

The probability and consequences of the accidents are assessed based on a combination of general experience, statistical models and engineering judgements.

Modifications to Existing Installations

Three areas were assessed separately:

- new subsea pipelines,
- new installations on existing platforms, and a new bridge, and
- possible changes in risk levels for existing installations.

The consequences of releases from the new installations are estimated to be of the same nature, but less than those from existing installations.

By taking into consideration risk changes for existing installations, the additional risk for existing Gorm installations due to production on Rolf was evaluated.

Safety Analysis of DAN-F

DAN-F is a further development of the very first oil field Dan in the Danish sector of the North Sea. The new platform complex comprises two wellhead platforms and one platform with process equipment and living quarters all of the steel jacket type. Unstabilized crude oil from the old DAN-field will be transported to DAN-F where separation into gas & oil will take place together with DAN-F own production. Gas will be transported through pipelines to GORM and THYRA on transfer to Denmark.

To a very great extent the safety analysis was performed according to the guidelines of the Norwegian Petroleum Directorate (NPD). In essence, these guidelines give a check as to whether the conceptual design is up to modern standards. The check is made by imposing different types of accidents on the platform. The consequences are evaluated with respect to environment, human lives or loss of a platform. The probabilities of the accidents are analysed taking into account the past experience with due respect to actual conditions and new design. If the probability falls below 10^{-4} per year the accident is not analysed further.

The accidents for which the platforms were checked included:

- blowout,
- fire and explosion,
- dropped objects,
- ship collision, and
- helicopter crash

3.2. Risk Analysis used as a Tool in Selection between Alternative Traffic Systems

At Guldborgsund between Lolland and Falster the Danish Road Directorate is planning to build a new road connection.

In order to supplement the tenders from the construction companies and as a basis for a selection between alternatives the Risk Analysis Group performed a risk analysis. The analysis took into account three possibilities: a bridge, a one-tube tunnel, and a two-tube tunnel with separated traffic.

By the investigation it was found that only two risk categories gave significant differences between the alternatives.

These two categories were catastrophic accidents such as fires, explosions, or releases of toxics from accidents involving trucks, which give higher consequences in a tunnel than on a bridge, and the risk caused by accidents, where the two tunnels have a lower accident rate than the bridge.

The resulting conclusion was that the safest road connection at Guldborgsund would be a two-tube tunnel, where the traffic is seperated to avoid head-on collisions.

3.3. Implementation of the Seveso Directive

A project for the National Agency of Environmental Protection was started concerning implementation of the directive on risks in connection to certain industrial activities in Denmark. The work will be performed in two phases. The first phase was carried out in 1984 and included the following:

- review of the EEC-Directive with respect to identification of guidelines for classification of industries,

- review of similar work in other European countries,

- discussions on possible interconnections with the area of occupational health and safety, and

- detailed plan for the second phase with the aim of writing guidelines for industry and authorities on requirements and the contents of the corresponding documentation.

The work was reported in January 1985, and phase two will continue with special emphasis on description of a general risk analysis, its elements, methods, models, and areas of limitations.

4. COMPUTER PROGRAMS

The computer programs used by the risk analysis group are briefly reviewed below.

ADINA

ADINA is a finite-element program for calculation of stresses and deformations in structures during static as well as dynamic loadings.

CASA

CASA is a program package for calculation of jet fires, pool fires and explosions.

CCET

CCET is an interactive program for construction of a new type of diagram for description of accident sequences, the cause-consequence-event tree (CCET). These diagrams are just as flexible as the cause-consequence diagrams, but in addition the diagrams are more compact and easy to overlook like event trees. In Fig. 3 a cause-consequence-event-tree constructed by the CCET program is presented.

FAUNET

FAUNET is an analytical program for reliability analyses of fault trees and networks. The program utilizes a very effective modularization process for reduction of the fault tree before the synthesis and evaluation of cut sets are performed.

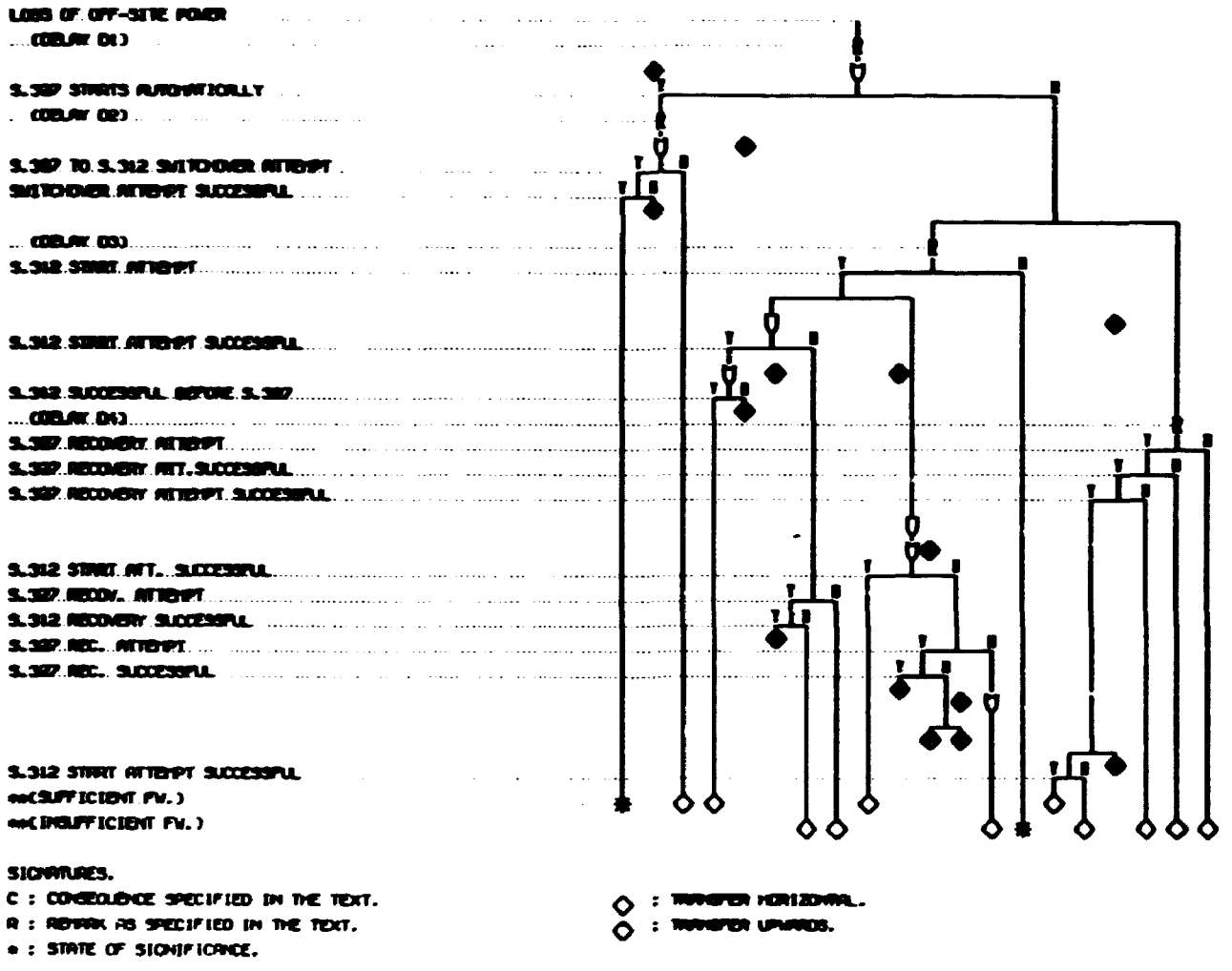

Fig. 3. Cause-consequence-event-tree constructed by the CCET programme.

FLAME/LENGTH

FLAME/LENGTH is a program that calculates the length of a jet flame. The calculations are based upon Lees formula, modified giving due consideration to Crist and Shermans approach.

FLAME/RADIATION

FLAME/RADIATION calculates the heat radiation from flames based upon the Stefan-Boltzmann formula and a numerically integrated view factor: The flame geometry is approximated by means of a series of tilted cylinders of variable diameter and length.

HECATE

HECATE is a heavy gas dispersion program coupled to a momentum jet mixing program used for the evaluation of heavy gas dispersion. It is based on a Van Ulden top hat type model with turbulence parameters based on Risø's experimental results.

MOCARE

MOCARE is a Monte Carlo simulation program for reliability calculations of systems with complex design or operation. Very flexible modelling by subsystem models is possible.

MORA

MORA is a program designed for calculation of two-phase blowdown phenomena.

RIKKE

RIKKE is an automatic fault tree construction program, primarily for mechanical systems.

The program works on the basis of a flow sheet for the system, which is loaded interactively into the computer via a graphic display screen. The program then draws on a library of component models, which are used in the following automatic construction of the fault tree for the system. It can treat electrical, elec-

tronic systems, process plants, operating procedures and computer programs.

SALP-MP

SALP-MP is an analytical program for calculation of the reliability of systems. The program can be used for multiphase problems and a certain combination of the modularization process by the FAUNET program, and the SALP-MP has proved very effective for calculations on very large fault trees.

5. PUBLICATIONS

Haastrup, P. Design Error in the Chemical Industry, Risø-R-500, Risø National Laboratory, DK-4000 Roskilde, Denmark. July 1984.

Petersen, K.E. (1984). Notes on workshop on PRA in licensing, Täljöviken, Sweden SÄK-1-(84)3.

6. STAFF

Head:

P.E. Becher. M.Sc. Mech. Eng.

Airforce Equipment Command 1970-71. Risø from 1971. Department of Energy Technology 1971-1984. Risk Analysis Group from 1984. Main areas of work: Structural reliability. Reliability and safety analysis of nuclear plants. Safety analysis of industrial plants.

Deputy head:

K.E. Petersen. Cand Scient.

Risø (first appointment) from 1977. Department of Energy Technology 1977-84. Risk Analysis Group from 1984. Work in the following fields: Development of computer codes for reliability analyses, models for mechanical components and data collecting systems for reliability data.

Permanent staff:

C.D. Grønberg. M.Sc. Elec.Eng.

Risø (first appointment) from 1967. Electronics Department 1967-1978, Safety Department 1978-1983, Risk Analysis Group from 1984. Work in the following fields: Nuclear Reactor Instrumentation, Human Factors, Emergency Planning and Exercises. Interest: Emergency Management and Communication.

Axel Damborg. M.Sc. Chem.Eng.

Risø (first appointment) from September 1984. Work in the following field: Safety analysis of chemical process plants and consequence models of the environment.

Tage Elm. B.A. Elec.Eng.

Consultant at Risø until March 1984. Main area of work: Component reliability.

H.E. Kongsø. M.Sc. Mech.Eng.

Risø (first appointment) from 1957. Research reactor DR 2 1957-1963, Department of Energy Technology 1963-1984. Risk Analysis Group from 1984. Work in the following fields: Computer codes for reliability and consequence assessment, risk assessment of nuclear and industrial plants.

D.S. Nielsen. M.Sc. Elec.Eng.

Risø (first appointment) from 1962. Electronics Department, 1962-84. Instrumentation 1962-70. Reliability and Safety Group, 1970-84 responsible for development of analysis methods and analysis of practical systems. Risk Analysis Group from 1984. Work in the field: Process plant reliability and safety analysis. Interest: Offshore production systems.

L.S. Schepper. M.Sc. Chem.Eng., Phd.

The Technical University of Denmark 1977-79. The University of Cambridge 1979. Risø from 1980. Department of Energy Technology 1980-1984. Risk Analysis Group from 1984. Main area of work and interest: Risk Assessment of Chemical Plants.

J.R. Taylor. B.A. in Engineering science, Oxford.

Babcock and Wilcox 1964-68. Atomic Energy Research Establishment, Harwell, England 1968-72. Risø 1972 until May 84. Main areas of work: control system design for chemical and power plants, computer system reliability and safety analysis, and industrial risk analysis.

N.K. Vestergaard. M.Sc. Chem.Eng.

Akvadan 1983-1984, R&D-Environmental Engineering.
Risø from 1984. Work in the following fields: Computer programs for reliability and safety analysis. Process plant reliability and safety analysis. Interest: Software for safety evaluation, process plant safety and toxic effects from releases.

Postgraduate Students:

Palle Håstrup. M.Sc. Chem.Eng.

Ph.D. student at The Technical University of Denmark and Risø in collaboration (first appointment) 1982-84. Main areas of work: Safety analysis of chemical process plants and automatic fault tree analysis. Interest: Design Errors.

B. Rasmussen. M.Sc. Chem.Eng.

The Technical University of Denmark (first appointment) from 1981-84. Ph.D. student at Risø and The Technical University of Denmark in collaboration from 1984. Work in the field of chemical reactions and proces systems. Interest: Unwanted chemical reactions in the chemical process industry.

Programmer:

P.T. Hansen. Programmer

Educated by Maersk Data 1975. Maersk Data (1975-78). Kommunedata (1978-1983). Risø from 1983. Interest: Calculations and simulation models, including consequence calculation systems.

K.L. Nielsen. Programmer

Educated 1983. Risø from 1983. Central Computer System (1983-84). Interest: Computer programs for reliability and safety analysis by automatic fault tree and consequence analysis.

Povl Dines Larsen. Programmer

Risø until June 1984. Main area of work: Graphical systems for automatic fault tree analysis.

Secretaries:

Gytha Egelund

Anette Grohnheit

7. REFERENCES

/Jensen/ Jensen, U.S., RELCON computer program developed by ELSAM, Denmark, 1984.

/Smith/ Smith, W.R. and Missen, R.W. Chemical Reaction Equilibrium Analysis: Theory and Algorithms, J. Wiley and Sons, 1982.

Tryk: Grafisk Service Center, Risø.

Risø National Laboratory **Risø-M-** 2512

Risø-M-

Title and author(s)

Risk Analysis Group

Annual Progress Report 1984

Date
June 1985

Department or group

Risk Analysis Group

Group's own registration number(s)

24 pages + tables + illustrations

Abstract

The activities of the Risk Analysis Group at Risø during 1984 are presented. These include descriptions in some detail of work on general development topics and risk analysis performed as contractor.

Copies to

Available on request from Risø Library, Risø National Laboratory (Risø Bibliotek), Forsøgsanlæg Risø), DK-4000 Roskilde, Denmark
Telephone: (03) 37 12 12, ext. 2262. Telex: 43116

Available on request from.
Risø Library,
Risø National Laboratory, P.O. Box 49,
DK-4000 Roskilde, Denmark
Phone (02) 37 12 12 ext.2262

ISBN 87-550-1130-6
ISBN 0418-6435